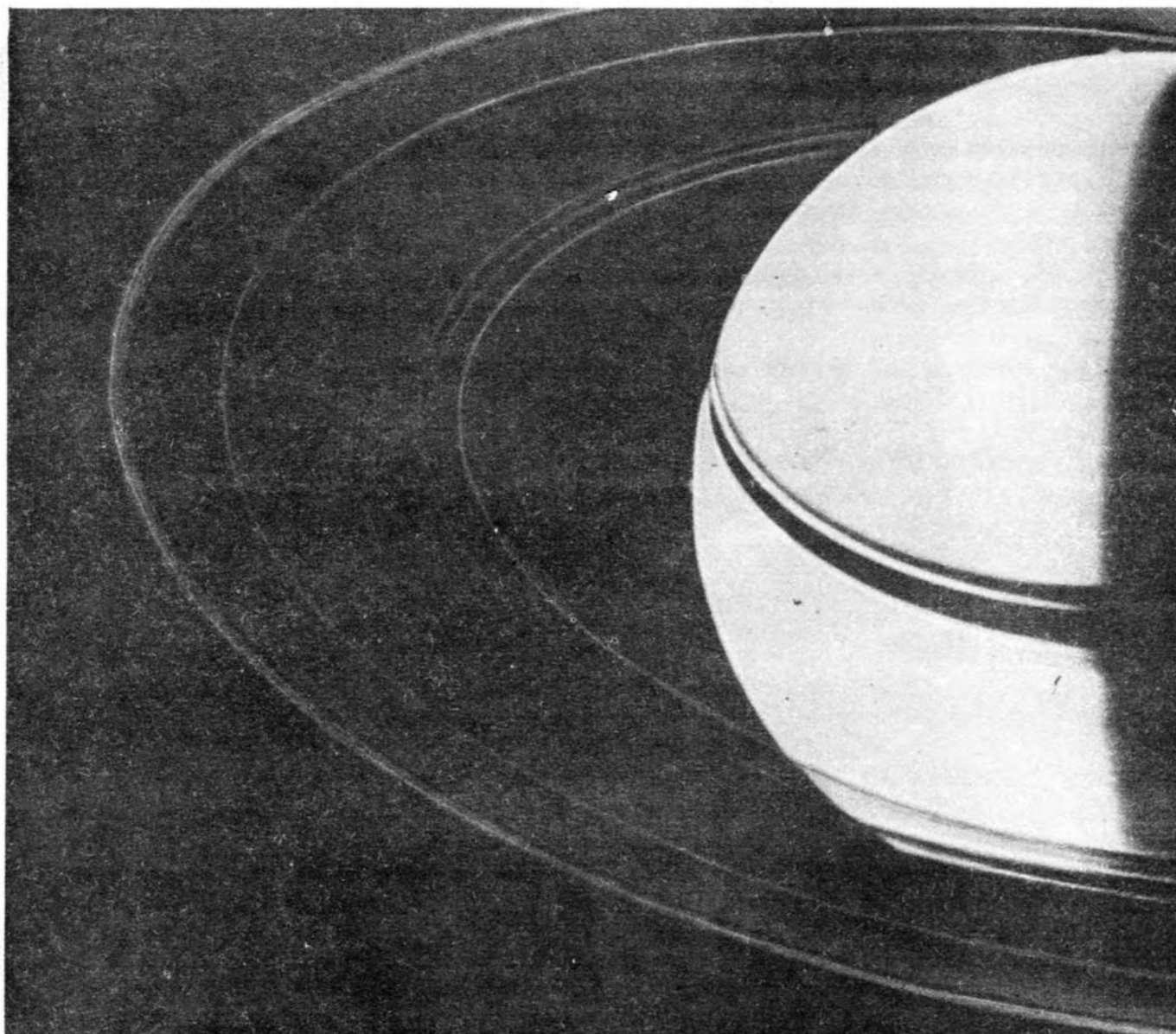


ISSN 0038-6340

SPACEFLIGHT

88905 Космические полеты № Т-11
(спейсфлайт)
По подписке 1981 г.



Published by
The British Interplanetary Society



VOLUME 23 No 9
NOVEMBER 1981

MARS IN 1995!

By Bob Parkinson

Why not send men to Mars? That is the question posed by this challenging article from B.I.S. Fellow Bob Parkinson. He argues that a manned Mars trip is not only possible using existing technology, but is also more desirable than sending a series of unmanned probes.

The article highlights the main points of such a trip. For interested readers, a detailed analysis appears in this October's issue of *Space Chronicle*.

Introduction

In 1970, at the height of the Apollo programme, NASA unveiled its plans for the next thirty years in space. Not only did it include development of a re-usable Space Shuttle, it also had permanent Space Stations, a nuclear inter-orbital vehicle, bases on the Moon and a manned expedition to Mars before the end of the century. That "before the end of the century" was a conservative estimate at that - the earliest NASA would propose for such a mission was 1983.

Then, in 1972, the nuclear NERVA stage was cancelled and all such plans were abandoned. At the moment even a return of men to the Moon in this century seems only a distant possibility.

About two years ago I began to wonder whether it had to be so. Viking had raised a host of questions about Mars, but to explore them with robot probes would demand a vast commitment of resources spread over decades. And back in 1952 von Braun had proposed manned missions to our neighbour planet using chemical propulsion with the very modest specific impulse of 2800 m/sec. Rocketdyne and NASA have tested the components for an Advanced Space Engine with a specific impulse in excess of 4660 m/sec, and that could make nuclear propulsion quite unnecessary.

This article is a brief description of the results of that study. It represents a *conservative* estimate for the requirements for a 1995 mission to Mars, using (as far as possible) of-the-shelf hardware. David Hardy helped by painting three marvellous impressions of key moments in the mission.

Available Hardware

You cannot plan a mission for 1995 without making some assumptions about the hardware which may be available by that time.

Chief among the assumptions are possible developments to the Space Shuttle. While launch costs are not an overwhelming factor in planning the mission, it is going to be necessary to launch some large boost stages (about the size of the Saturn IV-B stage) and the diameter of the Mars Landing Module is likely to be considerably bigger than the Shuttle cargo hold. Fortunately, NASA have already been looking at a Heavy Lift version of the Shuttle (*Spaceflight* 1978, p.135) in which the recoverable orbiter would be replaced by a "propulsion capsule" carrying the Main Engines and avionics, and the cargo would be carried externally.

The second assumption concerns the availability of an Orbital Transfer Vehicle. It now looks probably that NASA is going to adapt Centaur for operation with the Shuttle, but if it is to launch some of the larger, heavier payloads proposed for geosynchronous orbit in the late 1980's, Centaur will have to get fatter and heavier. Studies have already been carried out on such a stage, and these have been used to provide propulsion for the mission.

The final assumption concerns the development of free-flying Space Stations. There is considerable pressure growing in the USA now to develop a Space Operations Center as a successor to the Shuttle, but as yet the size and mass of such a Center has not been defined. Instead, I have used the data on Spacelab and the proposals to convert it into a free-flying module with the addition of a large, unfoldable solar array (*Spaceflight* 1979, p.349) to provide a European dimension to the project.

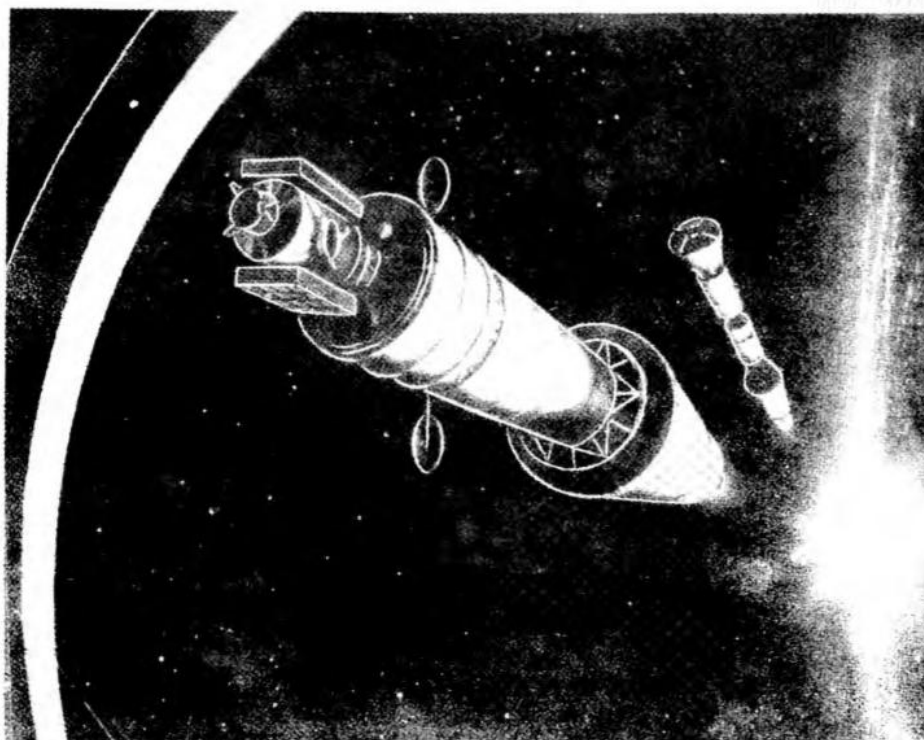
Mission Outline

In many ways the mission planning must follow the outline indicated by the planning for nuclear missions in the late

Continued on p.311

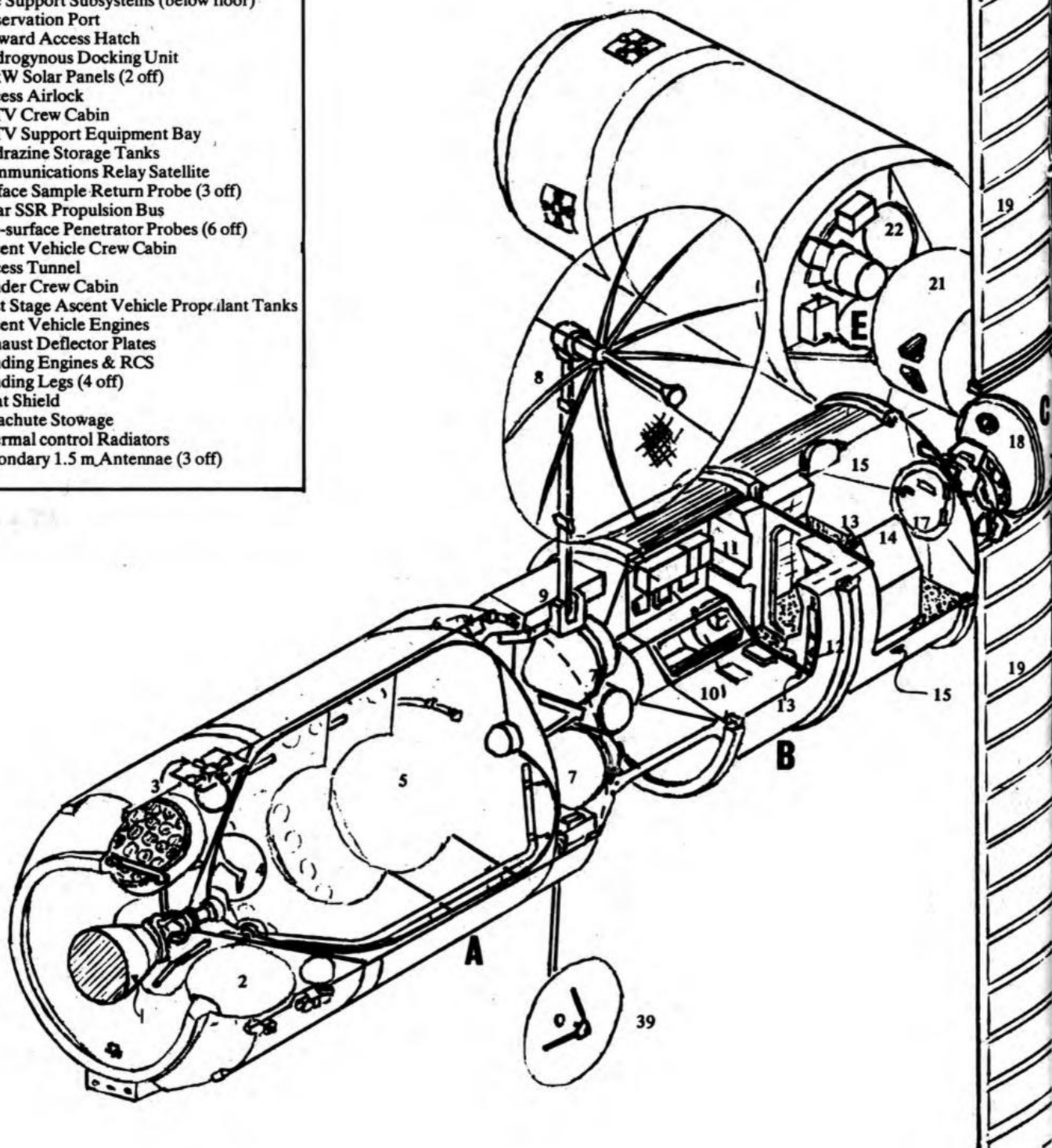
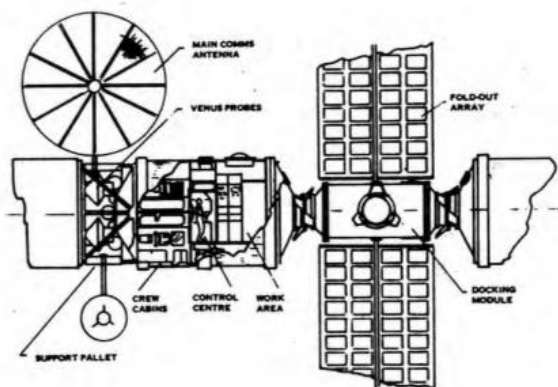
Viewed from a porthole in Orbiter 1, the other two ships come "out of the Sun" as they leave Earth orbit.

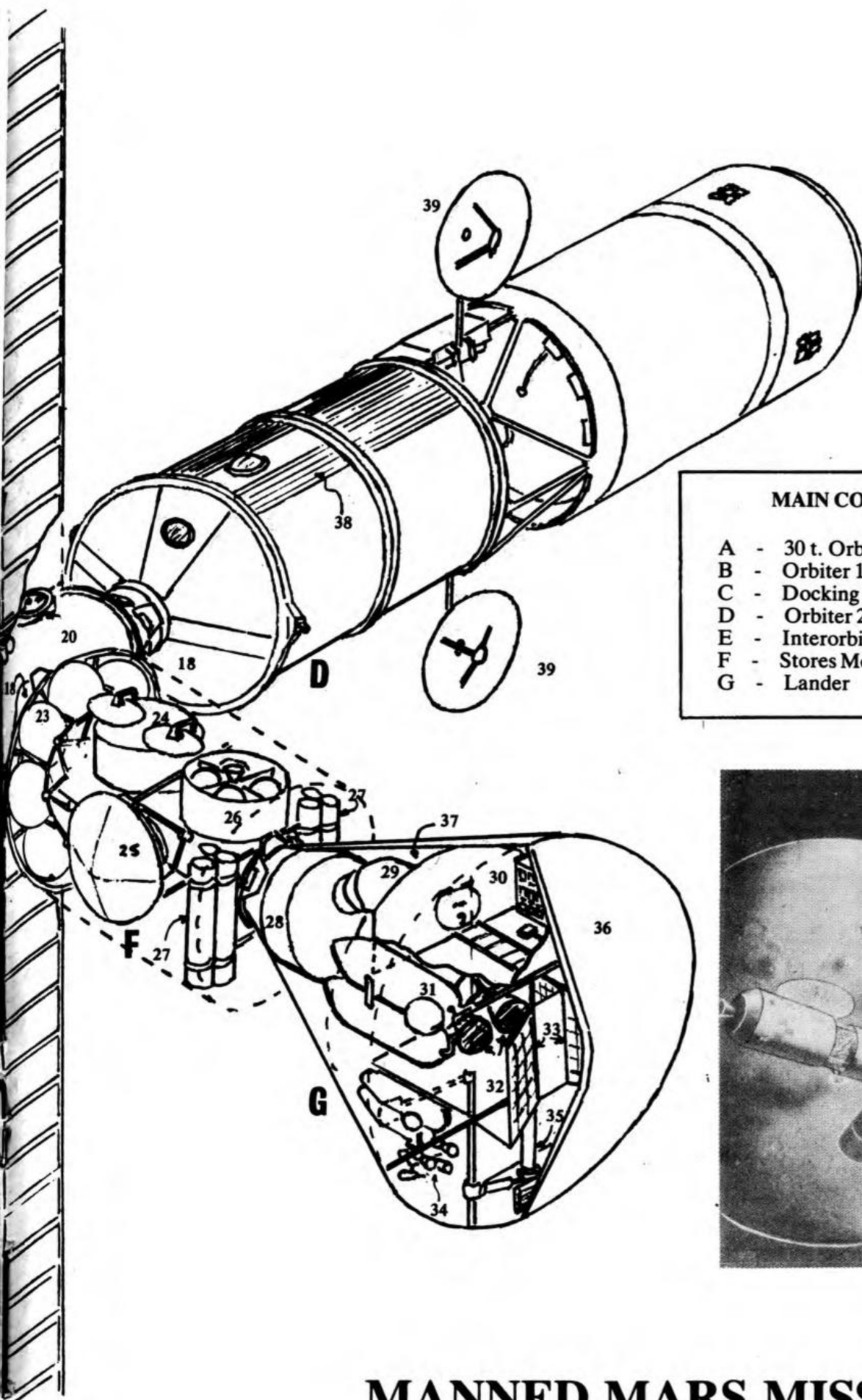
Copyright David Hardy



KEY

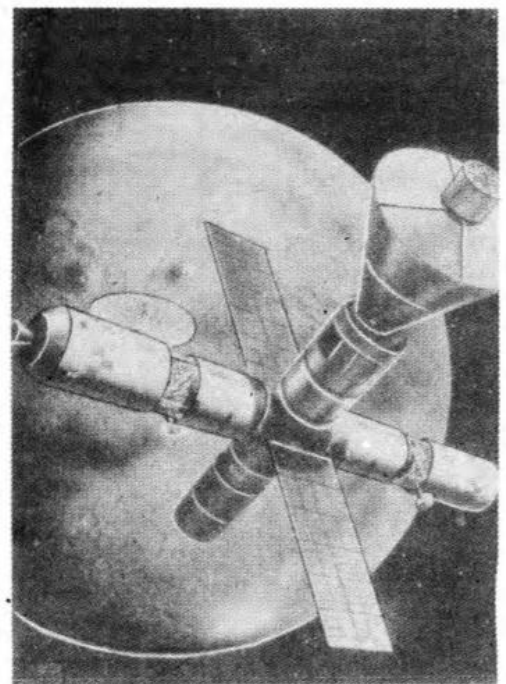
1. Advanced Space Engine
2. Toroidal Liquid Oxygen Tank
3. RCS Thrusters
4. Helium Pressurization Tank
5. Liquid Hydrogen Tank
6. OTS Control Electronics
7. Venus Probes (2 off)
8. Main 6 m. Communications Antenna
9. Support Equipment Pallet
10. Crew Cabin (3 off)
11. Control Centre
12. Water Storage Tanks
13. Polythene Radiation Protection Bulkheads
14. Electronic Equipment Racks
15. Life Support Subsystems (below floor)
16. Observation Port
17. Forward Access Hatch
18. Androgynous Docking Unit
19. 17 kW Solar Panels (2 off)
20. Access Airlock
21. IOTV Crew Cabin
22. IOTV Support Equipment Bay
23. Hydrazine Storage Tanks
24. Communications Relay Satellite
25. Surface Sample Return Probe (3 off)
26. Polar SSR Propulsion Bus
27. Sub-surface Penetrator Probes (6 off)
28. Ascent Vehicle Crew Cabin
29. Access Tunnel
30. Lander Crew Cabin
31. First Stage Ascent Vehicle Propellant Tanks
32. Ascent Vehicle Engines
33. Exhaust Deflector Plates
34. Landing Engines & RCS
35. Landing Legs (4 off)
36. Heat Shield
37. Parachute Stowage
38. Thermal control Radiators
39. Secondary 1.5 m. Antennae (3 off)





MAIN COMPONENTS

- A - 30 t. Orbital Transfer Stage
- B - Orbiter 1 Module
- C - Docking Module
- D - Orbiter 2 Module
- E - Interorbital Transfer Vehicle
- F - Stores Module
- G - Lander



Copyright David Hardy

MANNED MARS MISSION 1995

R.C. Parkinson 18.6.81

MAN ON MARS - A BRIEF CHRONOLOGY

1925

Walter Hohmann, in *Die Erreichbarkeit der Himmelskörper*, outlines the minimum energy orbits for interplanetary travel, and thus lays the groundwork for engineering design of future missions.

1948

V. Cleaver and L. Shepherd publish a series of papers on "The Atomic Rocket" in the *BIS Journal*, laying the foundations for nuclear propulsion in space.

1952

W. von Braun publishes *Das Marsprojekt*, which describes the construction of ten, chemically-fuelled rocket ships in orbit about the Earth capable of carrying seventy men on a three-year mission to Mars, including up to 400 days on the Martian surface. The fleet would have required some 950 launches of a huge Earth-to-Orbit ferry rocket bigger than Saturn V. In 1956, with Willy Ley (*The Exploration of Mars*) he scales this expedition down to just two ships and twelve men. These are the first complete engineering studies of a mission to Mars.

1955

Project Rover is started as a joint venture between the US Atomic Energy Commission and the US Air Force to investigate the prospects for nuclear rocket propulsion.



NASA manned mission 1969.

Oct. 1960

USSR attempts to launch first space probes to Mars. At both attempts the launch vehicles fail to achieve Earth orbit.

1961

Ernst Stuhlinger proposes plans for a manned Mars mission using nuclear-electric propulsion. His proposal would have constructed five 360 tonne vehicles in Earth orbit carrying a crew of fifteen and three landing vehicles on a 572 day round trip, with 29 days on Mars. Later studies show the powerplant mass to be unrealistically low.

May 1961

President Kennedy recommends the start of the NERVA nuclear rocket project. Contracts are awarded to Aerojet-General and Western Electric for the development of a 120 kN thrust, 1.1 GW engine. First hot firing of KIWI-B reactor takes place late in the same year.

Nov. 1962

The USSR spaceprobe Mars 1 is successfully launched towards Mars and passes within 193,000 km of the planet, but fails before encounter at the midcourse manoeuvre.

1963-4

R.L. Sohn and W.M. Hollister independently discover a class of round-trip orbits which use a Venus swing-by on either the outbound or inbound legs to reduce both flight times and delta-V requirements for a manned mission to Mars, improving considerably over Hohmann's original plan. These orbits become the basis for future planning.

Nov. 1964

Mariner 4 is launched to become the first successful fly-by probe of Mars. Encounter takes place on 14 July 1965 when the spacecraft comes within 9600 km of the surface and observes a heavily cratered surface but no canals or free water.

1967

M.W.J. Bell publishes a Rocketdyne study for an evolutionary programme of manned interplanetary exploration using chemically-propelled vehicles launched by the Saturn V rocket. Missions would have required

rendezvous and assembly of interplanetary vehicles in Earth orbit. At this time there are a variety of studies underway for future expeditions to Mars as part of NASA's forward planning.

1969

The President's space task group advises launching a manned mission to Mars "before the end of the century" as part of future US activity in space. Earliest possible dates would have been in the early 1980's. NASA publishes plans for an Integrated Space Transportation System in which the preferred Mars mission profile uses two identical vehicles based round the nuclear NERVA stage for a 12 man expedition carrying out 30 days of exploration on the Martian surface in a total round-trip of about 560 days. Lander would have used Apollo technology or a lifting-body vehicle to give a greater choice of possible landing sites.

1971

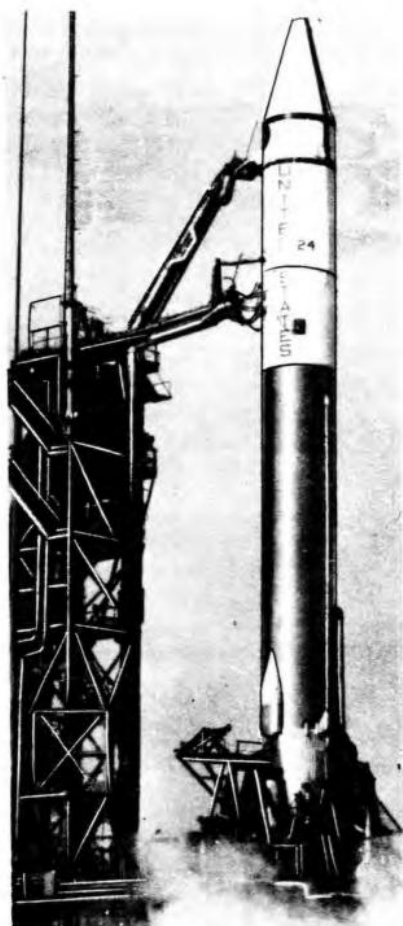
Among studies for possible manned Mars missions, R. R. Titus proposes a "Fly-by, Excursion Mode Lander" (FLEM) vehicle as a means of achieving an early landing. The main vehicle does not stop at Mars, but an "excursion module" is detached a few weeks before encounter to go on ahead and carry out the landing. FLEM missions would have required only two Saturn V launches to carry out.

May 1971

USSR probe Mars 3 is launched. This probe successfully ejects a small lander which continues transmitting until 20 seconds after reaching surface, but owing to the presence of a planetwide dust storm at the time no useful information is returned from the surface.

May 1971

Mariner 9 is launched to become the first successful Mars orbiter, beginning a detailed survey of the Martian topography in Jan. 1972. It discovers *Mons Olympica*, *Vallis Marineris* (to which it gives its name), and evidence of free water run-off channels created in the not too distant past in some areas.



Mariner 9 launcher pad test.



Phobos as seen by Mariner 9.

1972

NERVA development cancelled. NASA abandons plans for manned missions to Mars.

1975

Plans for a robot surface-sample-return probe based on Viking hardware are published in the AIAA magazine *Aeronautics & Astronautics* as a follow-on in the exploration of Mars.

August 1975

Viking 1 launched to make a successful landing on *Chryse Planitia* on 20 July 1976. Viking 2 follows less than a month later. The Viking mission, originally planned for 90 days operation on and about Mars, continues making observations until late 1979 with a high degree of success. The entire surface is photographed to a resolution of 200m and a significant fraction at resolutions down to 8m.

The orbiters also make close encounters with the two Martian moons, obtaining the highest resolution pictures ever taken of another object from a robot spacecraft.

1978

Twenty-seven scientists from the post-Viking Mars Science Working Group identify a wide-variety of missions for future Mars probes, but give highest priority to surface sample return missions.

1980

R. C. Parkinson presents paper "*Is Nuclear Propulsion Really Necessary? (or Mars in 1995!)*" at the AIAA 16th Joint Propulsion Conference, showing that manned missions to Mars are possible using a chemical propulsion in the Shuttle era. Results of the detailed "feasibility study" are presented at BIS Symposium on "Space Transportation Systems for the 1990's" in April 1981.

1981.

A four-day conference on manned Mars exploration under the title *The Case for Mars* is held at the University of Colorado sponsored by the University of Colorado Space Interest Group, the Planetary Society, the Viking Fund and the National Space Institute. The consensus is that "a Manned Planetary Program will provide both a unifying symbol and a future objective for the United States space program."



The Martian surface - the first picture taken by Viking 1 after landing.

Continued from p.307

1960's. The mission would be assembled in low Earth orbit from a number of Shuttle launches, and depart for Mars on about 4 November 1994. Instead of the two vehicles proposed in the 1970 NASA plans, this mission would have three - two 'Orbiter' vehicles and one vehicle carrying the Lander and associated cargo on a one-way trip to Mars. The two Orbiter vehicles would provide living space for the five-man crew and give a 'mutual lifeboat' capability in the event of a major system failure. During the long periods of 'cruise' the three vehicles would dock together into a cruciform configuration (see centre pages) to allow the crew to move freely between one section and the next.

Each Orbiter vehicle consists of a single long Spacelab module fitted out to give the crew separate quarters and to provide life support and a control centre, with a half-length Pallet carrying additional equipment. One of the Orbiters would carry most of the scientific and communications equipment and a crew of three, while the second Orbiter would carry the Docking Module, which also carries the fold-out solar array providing power for the mission during the long periods of cruise.

At launch, each Orbiter vehicle has three propulsion stages. The first - a Heavy Boost stage the size of Saturn IV-B - accelerates the vehicle onto its transfer trajectory towards Mars. The second and third stages are nearly identical, and are based around the Shuttle Orbital Transfer Vehicle. The second stage parks the expedition in a 13½ hr orbit about Mars, and the third is used for departure from Mars orbit and return to Earth.

The Lander vehicle uses the same first and second stage boosters as the Orbiter vehicles, but omits the third stage. Furthermore, because the Lander assembly is lighter than the other two, the second stage booster actually has spare propulsion capability when it reaches Mars orbit, and can be

used to pick up the returning surface exploration team, and carry out a side mission to Phobos. In addition to the manned Lander, the Lander vehicle will carry a communications relay satellite for the period during which the expedition is in Mars orbit, and three robot Surface Sample Return probes capable of lifting kilogramme-sized samples of soil back into orbit for sites not visited by the main expedition. One of those sites is expected to be a location on one of the Martian icecaps (see *Spaceflight*, 1976, p.383).

The expedition will arrive in orbit about Mars on 10 June 1995. It has 45 days in which to select a landing site, carry out a landing, field the SSR probes and carry out a side visit to Phobos. Then the two Orbiter vehicles will leave Mars orbit, not directly to Earth but to swing-by Venus on the way home.

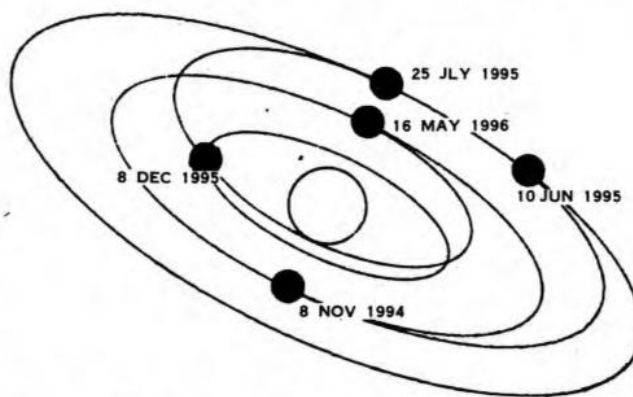
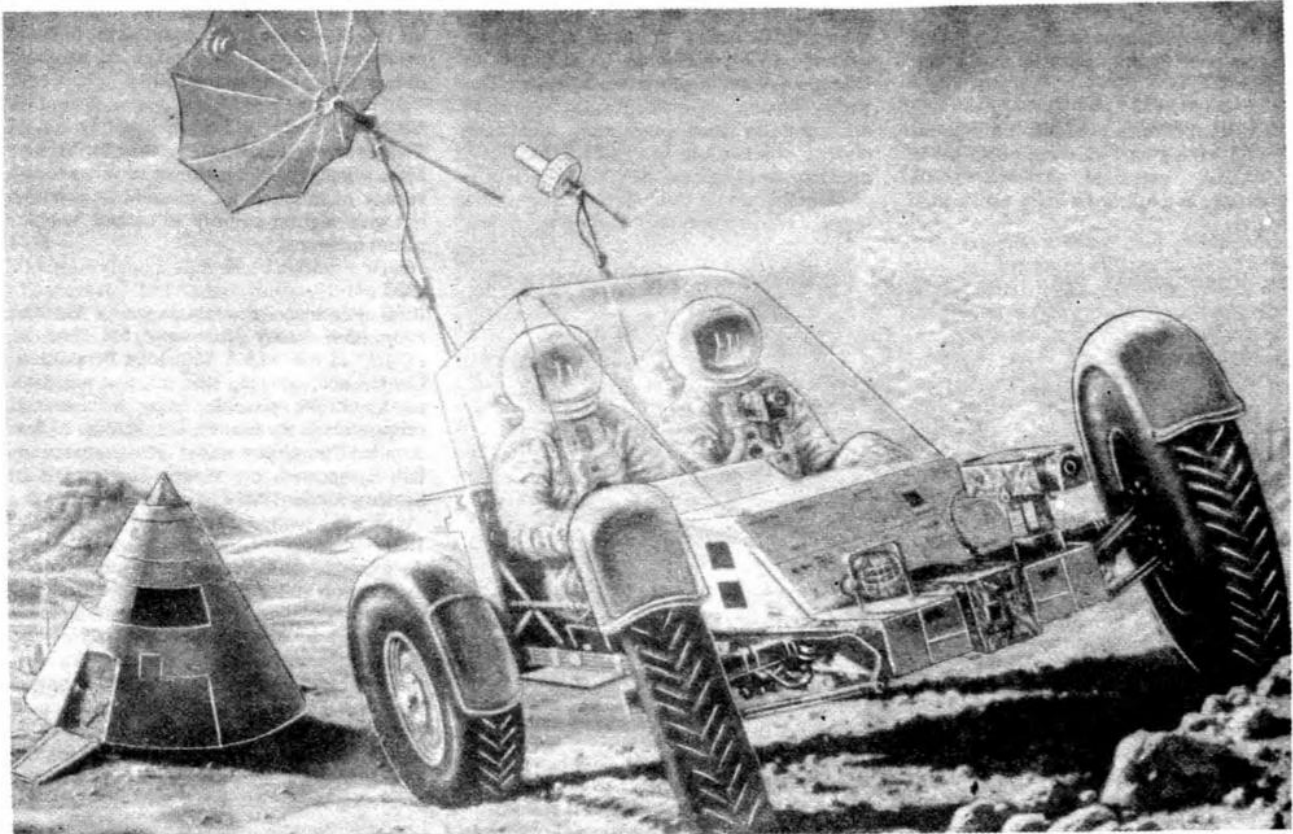


Diagram of the Earth-Mars-Venus swingby-Earth round trip planned for the mission. The Venus swingby means time and propulsion savings over a direct Earth return.



Landing site - Mars 1995. The lander has made a successful touchdown using a combination of aerodynamic and rocket braking. A large communication antenna has been set up and a drilling rig started, and now two members of the expedition are setting out in the Mars Rover for more distant points.

Copyright David Hardy

Close approach to Venus would occur about 8 December 1995, and would allow the mission to launch two Pioneer-sized entry probes at that planet. Then the orbit swings away from the Sun again and returns to Earth about 16 May 1996. The Venus-swingby trajectory is a plan worked out for the NASA nuclear mission, and saves both time and delta-V by shaping the trajectory closer to the ideal tangent as it encounters Earth for the second time.

Lander

The manned Mars Lander follows conservative principles by using the experience of Apollo and Viking for the capsule design. Shaped like Apollo, the capsule uses aerodynamic braking for the first part of the descent, using the minimal available lift and the capsule's RCS system to guide the flight

.....the manned mission is...less than five times the cost of Viking....[with] a value at least an order of magnitude greater....

path towards the precise chosen touchdown point. At 10 km altitude and a speed of Mach 2.5 the capsule releases a supersonic drogue parachute to bring it to subsonic speeds before deploying the main parachute canopy. It is now 4 to 5 km above the surface and has a descent speed of 60 m/sec.

With deployment of the main parachute, the Lander will jettison its heat-shield and deploy its landing legs. For the first time the crew will have a clear view of the terrain below (this may require periscopes or under-belly mounted TV cameras) and be able to select their landing site. When you consider that this really needs to be somewhere 'interesting' like the *Vallis*

Marineris it is apparent that the crew need considerable control at this point to make a safe landing. Finally, at about 600 m above the surface the landing rockets will be ignited, the parachute cut free, and the vehicle will manoeuvre for a conventional 'hot helicopter' landing.

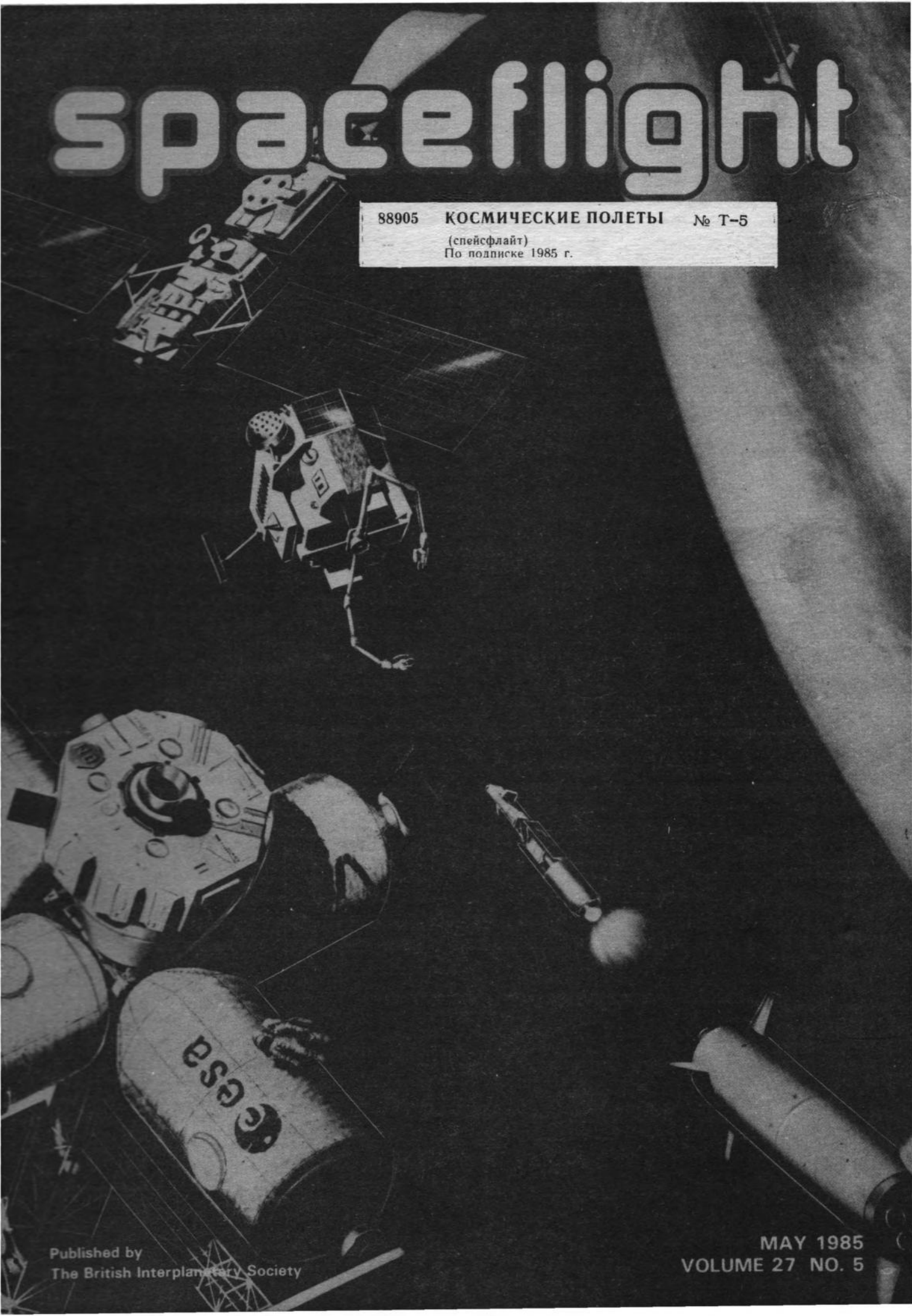
On board the Lander the crew of three will have about 500 kg of scientific supplies and an advanced version of the Lunar Rover to take them several kilometres away from the landing site in the course of their 20 day stay. At the end of that stay a two-stage ascent vehicle mounted in the centre of the Lander will carry them and 300 kg of samples up to the waiting Orbital Transfer Vehicle for recovery.

Cost

The immediate reaction of most people to such an ambitious mission is "wouldn't it be terribly expensive?" And so it would be if we had to develop all the components of the mission specially. However, the point of basing the study on units already planned for other purposes was to minimize the need for 'special equipment' as far as possible throughout. The major component which would be specific to the mission to Mars is the Lander - and even here I have drawn heavily of Apollo and Viking experience.

If we cost only the hardware used and the development of those mission-specific components like the Lander, the total cost is surprisingly modest. In 1980 dollars it comes to about \$5000 million. In the same units the Viking spacecraft cost \$650 million a shot, so that the manned mission is actually less than five times the cost of Viking. In terms of scientific achievement the manned mission must have a value at least an order of magnitude greater than Viking, and so it may be that by the 1990s something that spaceflight fans have always known will have come true - it will actually be cheaper to do it with men!

spaceflight



88905 КОСМИЧЕСКИЕ ПОЛЕТЫ № Т-5

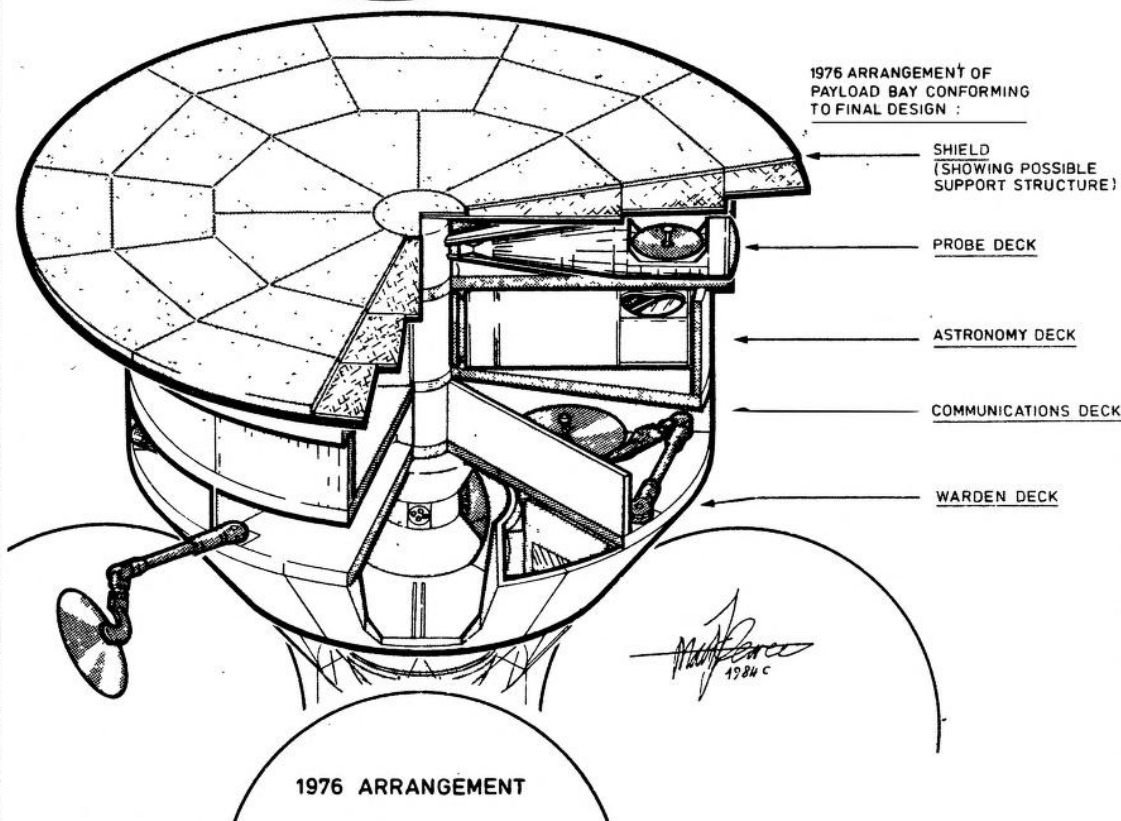
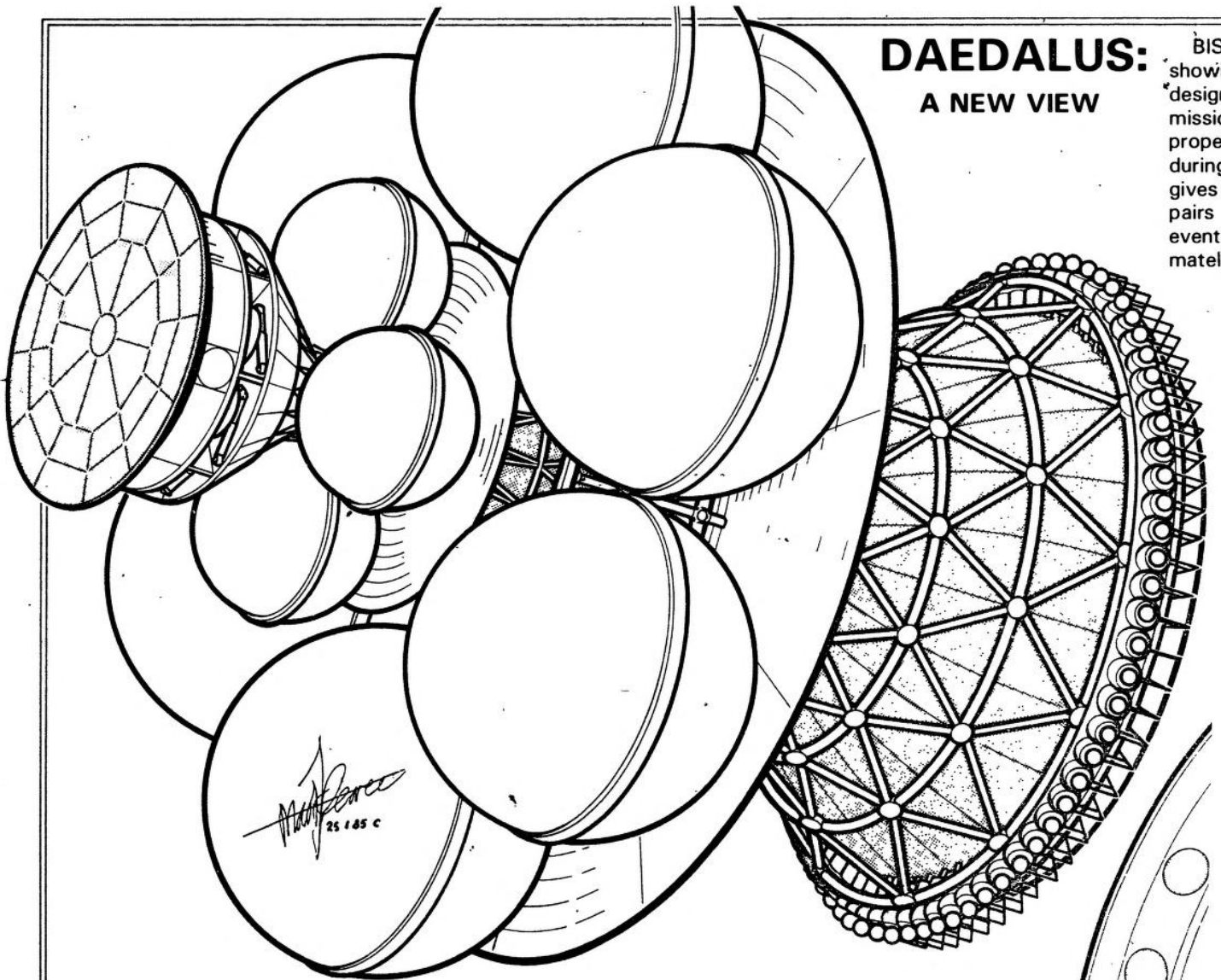
(спейсфлайт)
По подписке 1985 г.

Published by
The British Interplanetary Society

MAY 1985
VOLUME 27 NO. 5

DAEDALUS: A NEW VIEW

BIS
showi
design
missic
prope
durin
gives
pairs
event
matel



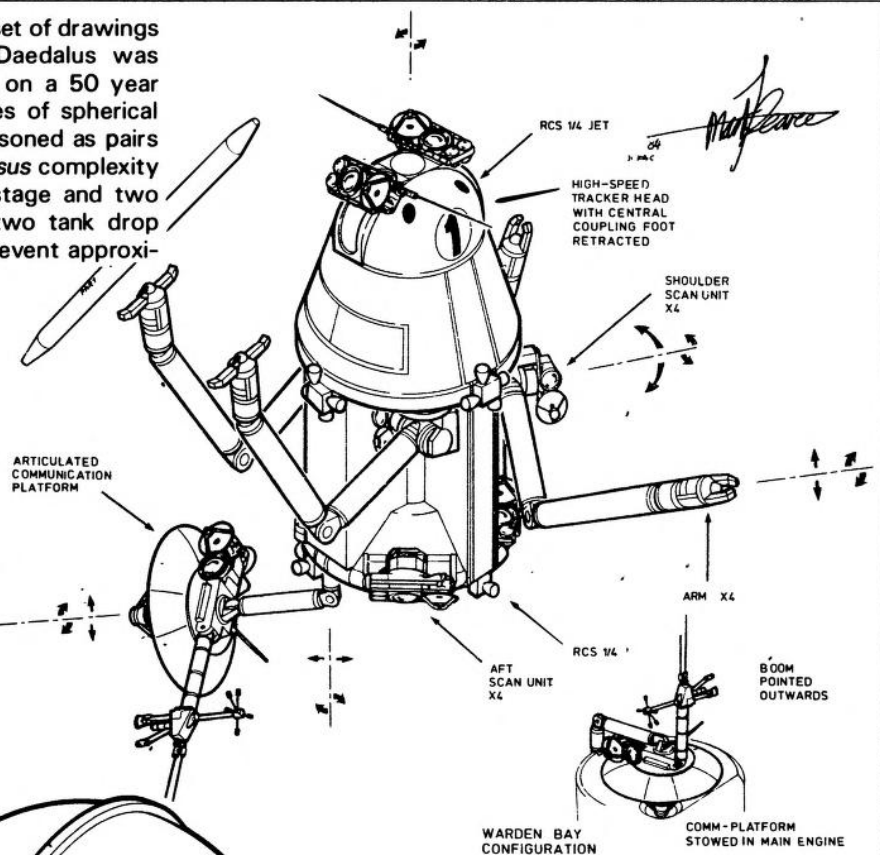
as possible, updati
instructions from E
encounter) in order t
from the payload re:
experiments and eq
flight that were not
mission.

The propulsion
would be limited, o
the propellant on th
over a period of s
capable of deployin
at distances of se
kilometres.

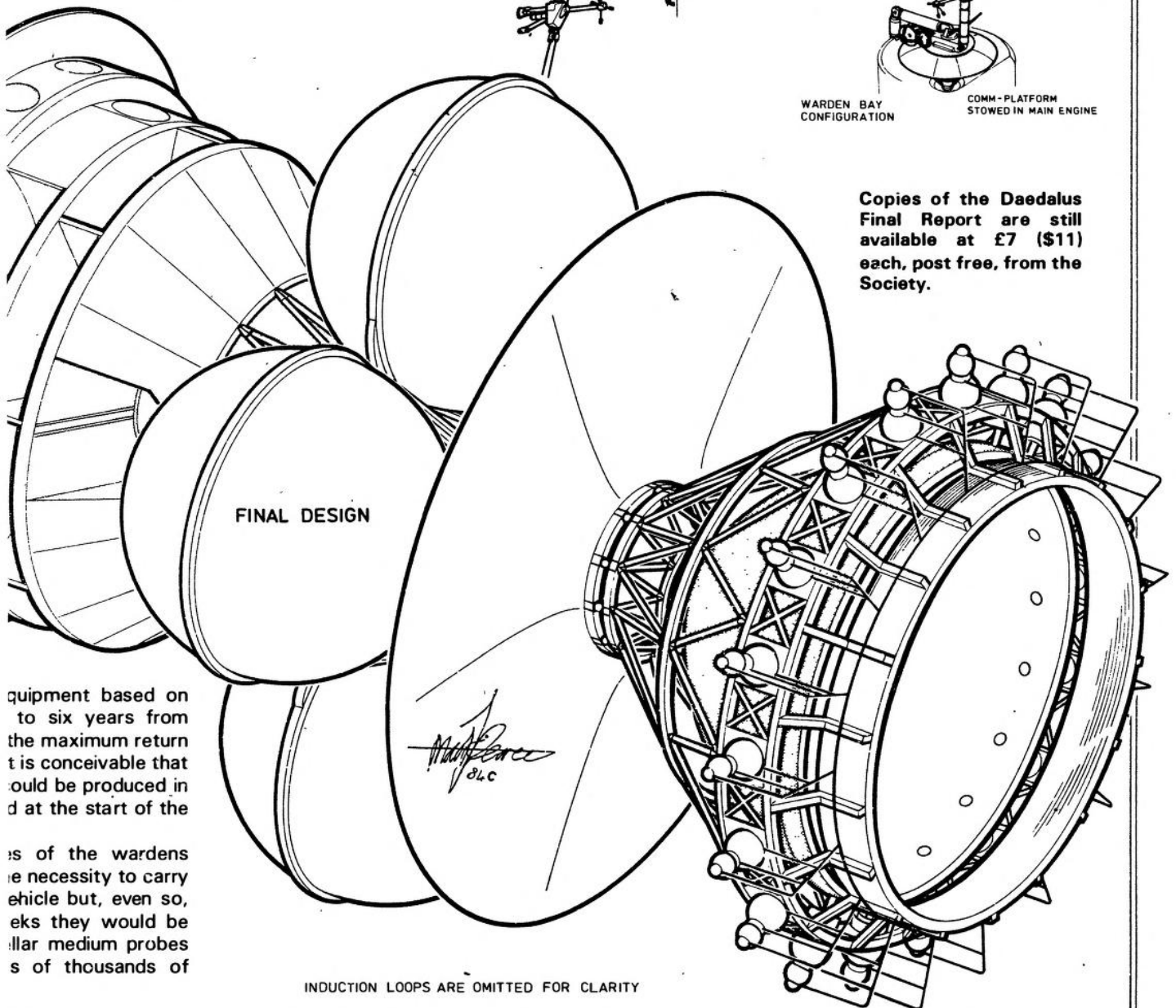
er Mark Pearce has produced this excellent set of drawings
 e Society's Daedalus star probe study. Daedalus was
 be an unmanned probe to Barnard's Star on a 50 year
 spelled by small nuclear explosions. A series of spherical
 tanks are arranged so that they could be jettisoned as pairs
 oost period. Examination of velocity gain *versus* complexity
 ign with three pairs of tanks on the first stage and two
 e second. This results in a vehicle having two tank drop
 ch stage of the boost, and a single staging event approxi-
 vavly through the boost period.

e propulsion system consists of a large reac-
 chamber surrounded by four magnetic field
 for controlling the expansion and flow of
 a from the engine. The fuel pellet ignition
 m evolved to be a ring of transmission lines
 oducing the relativistic electron beams used
 mpress and heat the fuel, around the exit
 the chamber.

e wardens have a high degree of autonomy
 the main computer for control and low level
 on making. They are also mobile and capable
 e flying from the main bus. They would add
 portant new dimension to payload flexibility
 configuring existing equipment and, as far



Copies of the Daedalus
 Final Report are still
 available at £7 (\$11)
 each, post free, from the
 Society.



quipment based on
 to six years from
 the maximum return
 t is conceivable that
 ould be produced in
 d at the start of the

s of the wardens
 e necessity to carry
 ehicle but, even so,
 eks they would be
 illar medium probes
 s of thousands of

INDUCTION LOOPS ARE OMITTED FOR CLARITY

SEATING FOR SPACE

By James Oberg

It is obvious where the commander and pilot sit during a Space Shuttle mission, but where do the rest of the crew sit and what roles do they play while seated?

Introduction

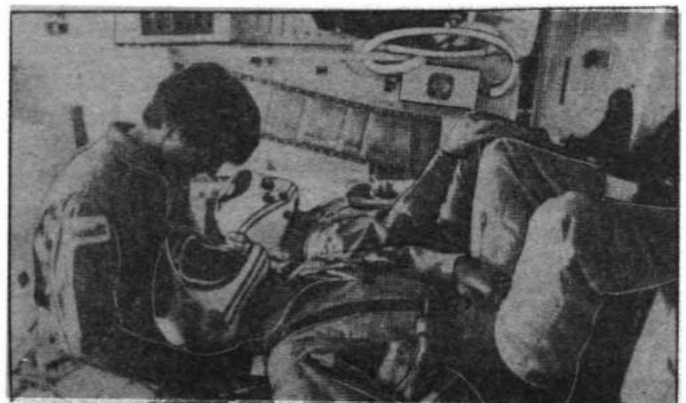
Seating arrangements for the CDR (commander) and PLT (pilot) on a Shuttle flight are the standard left and right positions, respectively. There is a third place that has a function during launch and landing - it can be called the 'flight engineer' position. This astronaut sits in the aft flight deck centre seat. He/she is an integral part of the ascent/entry flying crew (main responsibility: checklists) and is usually MS2 (Mission Specialist 2). MS1 (prime specialist for on-orbit mission operations) sits in the aft flight deck right seat.

As needed, up to four seats can be mounted downstairs on the middeck (only *Atlantis* was built for all four; all the others were built for three and the fourth set of brackets will have to be added). On orbit, both aft flight deck seats and all middeck seats are dismantled and stowed.

There is no obvious way of telling which of the crewmen fill which MS slots; that is generally decided by the mission commander after the crew has been assembled. Furthermore, two from every crew must be trained in spacewalking in case the payload bay doors need to be closed manually. One or two of the crewmembers must be trained in operating the remote manipulator arm if it is carried.

For the four Orbital Flight Test missions in 1981-2, the two-man crew had to be able to do everything. They all learned to perform spacewalks, although none had to do so; the last three pairs of astronauts mastered the use of the robot arm, and all gained experience. But then, with STS-5 in November 1982, things began to get both simpler (for each individual) and more complicated (for the crew as a whole).

There is no accepted standard seat numbering scheme, so the following is adopted here: 1=CDR; 2=PLT; 3=MS2(FE); 4=MS1; 5=MS3/PS; 6=PS; 7=PS; 8=PS/



Two middeck seats for Mission 41G.

NASA

rescue-1; 9=rescue-2 and 10=rescue-3.

There is a possible future seating variant of: 1=PLT1; 2=PLT2; 3=MS1(FE), 4=CDR; 5=MS2; 6=MS3/PS; 7=PS and 8=PS.

Also, for Space Station relief missions, the Shuttle can carry four to seven passengers besides the flight crew of three.

It turns out that crewmembers do not necessarily remain in the same seat for launch and landing. Lenoir and Allen developed the ascent/entry swap arrangement for STS-5 and it has become the usual, but not universal, practice. An interesting modification of plans occurred on STS 41D when two astronauts were scheduled to occupy the middeck. For convenience, seats 6 and 7 were supposed to have been used, with seat 5 left as open space to allow easier access. However, seat 5 has a view through the hatch window that seat 6 does not and the astronaut assigned to seat 6 objected to losing the chance for sightseeing. So seats 5 and 6 (and not 6 and 7, as planned) were occupied for launch and landing.

The issue of an eighth crewmember first came up on Spacelab 3 during the process of selection of two of the four payload specialists. Since both van den Berg and Johnston were so highly qualified it was suggested that both should fly, using an eighth seat be added. But that would have required qualification of seat-8's attachment points to the middeck floor and would also have interfered with the placement of the bunks so the suggestion was dropped. Spacelab D1 is the first mission on which eight seats will be installed and the seat will (this time only) be installed *not* at position 8 ('rescue 1') but forward of seat 5.

